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On Some Miscellaneous Lots of Earthworms Belonging to the American Museum of Natural History

By G. E. GATES

INTRODUCTION

So little is known about most earthworm species that the casual spori of other collecting often provides an opportunity to acquire scraps of much-needed information as to distribution, reproduction, anatomy, and variation in characters of taxonomic importance. Two of the species considered below have been known hitherto only from the original material. Another species, in spite of more frequent appearances in the literature, was even less adequately characterized.

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FAMILY ACANTHODRILIDAE

ACANTHODRILUS PERRIER, 1872

Acanthodrilus rouxi Michaelsen, 1913

Acanthodrilus rouxi MICHAELSEN, 1913, in Sarasin, Fritz, and Jean Roux, Nova Caledonia, Zool., vol. 1, p. 284.

SPECIMEN EXAMINED: Summit of Mt. Panis, 5400 feet, August 19, 1939, 0-1-0 (brittle, in two pieces); L. Macmillan. (A.M.N.H. No. 3516.)

EXTERNAL CHARACTERISTICS: Length, *ca.* 75 mm. Diameter, *ca.* 4 mm. Segments, *ca.* 150. Pigmentation unrecognizable (alcoholic preserva-

tion). Prostomium epilobous, tongue open and almost reaching 1/2. Setae present from ii, closely paired, the lateral perhaps a trifle more so than the ventral in ii-xii;

$$AA \text{ ca.} = BC, DD > \frac{1}{2} C,$$

ventral setae of xix and xxi penial, of ix copulatory. Nephropores, obvious from iii posteriorly, at *D*. First dorsal pore at ?12/13.

Spermathecal pores minute, superficial, at *B*, immediately behind intersegmental furrows on viii and ix. Female pores unrecognizable, but possible sites, at *A* on xiv immediately in front of setae, may be indicated by local modifications of epidermis. Prostatic pores minute, transverse slits at *B* on xix and xxi, anterior pores on a pair of rather conspicuous tumescences (without definite boundaries), tumescences lacking on xxi. Male apertures possibly represented by somewhat pore-like markings slightly lateral to *B* just behind 19/20. The *b* setae and probably the *a* seta present on right side of xx, ventral setae apparently lacking on left side.

Genital markings, if present, are small, circular, in a transverse row of four in presetal portion of ix (areas very indistinct and possibly only artifacts?).

INTERNAL ANATOMY: Septa 6/7-9/10 membranous, 5/6 not found, 10/11-13/14 muscular.

Gizzard large, anterior to 6/7 (in vi?). The cuticle that lines the gut at least into vii is thickened in the gizzard. Intestinal origin in xix (?), Typhlosole, which begins in xx, fairly high, lamelliform, ending abruptly in region of cxiii.

Dorsal blood vessel single. Supra-esophageal trunk present in ix-xvi. Extra-esophageal trunks pass onto gut in ix and unite into a median vessel that disappears in xiii. A subneural trunk and longitudinal vessels on parietes are unrecognizable. Hearts present in ix-xiii, the anterior pair more slender. A "lymph gland" is present on the anterior face of the septum in each segment behind cxiii and apparently is perforated by the dorsal vessel. Nephridia vesiculate, bladder J-shaped, the closed end of the loop laterally. Nephridial neck rather long, funnel scarcely wider than the neck.

Holandric. No testis sacs. Seminal vesicles, in xi and xii, small (juvenile?), vertical. Prostates looped, reaching back into xxvi. Duct straight except for one small ental loop. Male gonoducts of a side unite on entering xix and appear to pass into parietes just behind prostatic duct but can be traced, among superficial tissues, into xx. Penisetal follicles reach back into xxvi and pass into parietes on anterior faces of

prostatic ducts. Penial setae ornamented with triangular teeth of various sizes.

Spermathecal duct much longer than ampulla, slender ectally, and there with several short and loose loops, entalmost portion widened. Diverticulum, from duct close to ampulla, shortly digitiform to thumb-shaped. The spermatheca is long enough, when tissue binding loops has been cut, to reach to dorsal parietes. Follicles of ventral setae of ix are 1+ mm. long. The copulatory seta has four or five, more or less regular, longitudinal ranks of pits. Each pit is longer than wide, deeper entally where there is a knob with roughened surface, and with a thin half-collar around the ental portion.

REMARKS: The epidermis of the clitellar region is only slightly if at all thickened. No indications of sexual maturity were found internally.

DIPLOCARDIA GARMAN, 1888

Diplocardia udei Eisen, 1899

Diplocardia udei, GATES, 1955, Bull. Mus. Comp. Zool. Harvard College, vol. 113, p. 251.

SPECIMENS EXAMINED: Highlands, North Carolina, August 20, 1932, 3-5-6; G. E. Pickford. Franklin, North Carolina, in clayey soil (pH *ca* 6.0) in bank of wooded creek on road to Dillsboro, July 18, 1931, 0-1-0; G. E. Pickford. (A.M.N.H. No. 3562.)

The red color that was present in the clitellum of the previous specimens (formalin preservation) is lacking in this alcoholic material. The prostomium is epilobous, tongue open.

The gut, in the Franklin worm, is as wide in xiv as in xv. The typhlosole ends in the sixtieth of 180 segments. A piece of mica 1.5 mm. long and *ca.* 1 mm. wide was found in a portion of the intestine that is less than 3 mm. thick.

The male deferent ducts of a side, in two worms, are not in contact with each other throughout but cross under and over each other at irregular intervals. Spermatozoal iridescence in the ducts is brilliant and greenish, but on the male funnels is reddish.

FAMILY MICROCHAETIDAE

DRILOCRIVUS MICHAELSEN, 1918

Drilocrius breymanni (Michaelsen, 1897)

Criodrilus breymanni MICHAELSEN, 1897, Zool. Jahrb. Anat., vol. 10, p. 383. Type locality, Palmira, Colombia.

Drilocrius breymanni, MICHAELSEN, 1918, Zool. Jahrb. Syst., vol. 41, p. 357. After reëxamination of the original material.

SPECIMENS EXAMINED: Bitaco (Dept. del Valle), Colombia, in muddy bottom and in banks of small streams entering Rio Bitaco, 1500 meters, August 7, 1954, 0-2-2; Eugene N. Kozloff. (A.M.N.H. No. 3563.)

EXTERNAL CHARACTERISTICS: Diameter, $3+$ mm., *ca.* 5 mm. in region of wings. Pigmentation apparently lacking (formalin preservation). Body from vii or viii posteriorly nearly square, but dorsal face slightly wider than ventral face. Setae paired, at four corners of the body, ventral setae of xv more closely paired than elsewhere, ventral setae of xvi slightly more widely separated than elsewhere. (Nephropores not found.) Clitellum indistinct, epidermis translucent and slightly tumescent, annular, on xviii-xxiv or xxv (one specimen), xviii-xxvi (one specimen).

Female pore (?) anteromedian to right *a* on xiv (one specimen, not found in the others). Spermathecal pores dorsal, in *DD*, the lateralmost slightly beyond *D*, each in a very small tubercle of which there are eight to 10 on each of 13/14 and 14/15.

Ridges or wings, thick longitudinal protuberances in *BC*, possibly restricted to xvi which is, however, elongated. Body wall thickened in ridge region, but no glands are recognizable on the coelomic face.

INTERNAL ANATOMY: Gizzard (?) weak, a widened white portion of the gut in vi, gut also white but not widened in v. Esophagus narrow in xii-xiii, slightly wider in xiv-xvii, valvular posteriorly in xvii. Intestinal origin in xviii, the gut in xviii-xix moniliform, white, in appearance somewhat like gizzards but without obvious thickening of the muscular layer. Intestine behind xx brown and sacculated. Typhlosole begins in region of xxi-xxii and is never high. The ventral surface is rounded.

Subneural trunk larger than the ventral vessel anteriorly, adherent to the parietes, continued forward into iii. Hearts, apparently lateral, in vii-xi. Nephridia large.

Holandric. Seminal vesicles in xi and xii. The posterior vesicles either extend into xiii or pouch 12/13 back so as to appear to be also in xiii. Ovaries fan-shaped, plicate (with several egg strings?). Ovisacs lobed, larger than the ovaries, in xiv. Spermathecal ducts almost confined to the parietes, ampullae rather small.

REPRODUCTION: Sperm are present on male funnels and in spermathecal ampullae. Spermatophores small, with iridescence, are present on xv-xvi, in or near the longitudinal groove. Reproduction presumably is sexual and biparental.

REGENERATION: Tail regenerates (two specimens), small, with completely dorsal anus. The lost posterior portions of the other specimens

probably were broken off just before preservation. Worms of this species may autotomize readily.

REMARKS: *Drilocrius bürgeri* (Michaelsen, 1900), from Bogota, is distinguished from *breymanni* by restriction of spermathecal pores to 13/14. Very little is known about variation in this genus.

ALMA GRUBE, 1855

Alma emini (Michaelsen, 1892)

Siphonogaster emini MICHAELSEN, 1892, Mitt. Naturhist. Mus. Hamburg, vol. 9, pt. 2, p. 8. Type locality, Bukoba, Tanganyika.

SPECIMENS EXAMINED: Stanleyville, Belgian Congo, February, 1915, 21-9-9; H. Lang and J. Chapin. (A.M.N.H. No. 2267.)

EXTERNAL CHARACTERISTICS: Length, 65–290 mm. Diameter, 2–8 mm., maximum usually reached in region of xi–xiii. Segments, 340+ (posterior amputee). Body circular to transversely elliptical in cross section through first 15 segments, becoming quadrangular, with a pair of setae at each corner. The dorsum still farther posteriorly is depressed so as to form a broad trough bounded laterally by a rounded ridge bearing the *c* and *d* setae. Gills lacking. Anus a dorsal longitudinal slit with or without a spheroidal to transversely ellipsoidal terminal lobe. Secondary annulation: recognizable only in dorsum of i, a presetal and a postsetal secondary furrow present on iii and each of several other segments, in each of viii–xii furrows are more numerous, as many as nine and all of about the same depth but not so marked as the intersegmental furrows. Pigmentation unrecognizable (alcoholic preservation). Prostomium zygotobous, longer than the peristomium, tapering, and with a small, pit-like depression at apex. Setae present from ii on which *d* setae are dorsal, *a* and *b* of ii closely paired, elsewhere all setae widely paired; $DD > AA$, $CD > AB$ anteriorly but about reaching equality behind xx. Nephropores at or close to *B*, in so far as could be determined, usually unrecognizable.

Clitellum annular, intersegmental furrows and setae present, extending through lxxix–cxxi where the outermost portion of the thickened epidermis has a deep red color (preservation artifact). Thickening of the epidermis gradually decreases in both directions, and distinct boundaries are unrecognizable. Anteriorly the red color becomes restricted to equatorial bands in the dorsum which may be visible as far forward as lxx (one specimen) or even lxvi (one specimen).

Female pores, at *B*, on xiv, each in a transverse presetal depression within a rather definite, smooth, and glistening band of slight epider-

mal tumescence. (Male pores were not found.) Spermathecal pores minute, in *AD*, two to 22 per furrow (asymmetry frequent), at 57/58, 58/59–73/74, 74/75, 75/76. Each pore may be at center of a quite small hemispheroidal tubercle.

Claspers, often called penes in the past, comprise a stalk and terminal flat lamina. The stalk is about 20 mm. long, 1+ mm. thick, annulated (furrows closely crowded), and usually more or less concave on median side. The lamina, rolled up like a scroll, is 5–6 mm. wide and *ca.* 10 mm. long. Genital markings, on concave side of stalk, are circular, each with a markedly raised, central, hemispheroidal (or nearly so), tough knob. One marking usually is present near the base, another near the lamina, yet another (one specimen) between the usual two, an extra pair of markings distally on one clasper. Setal follicles open through the epidermis on the ventral side of the clasper. Setae: equidistant in a single row of four to six on the stalk (between middle and lateral genital markings, one specimen), irregularly distributed near distal end of lamina or in short rows near anterior and posterior margins, nearer the middle in two longitudinal rows of six to 11 (usually 10). Each seta, on the lamina, protrudes from center of a small hemispheroidal tubercle that is on a slight elevation or within a shallow depression. Similar tubercles on the stalk are withdrawn into deep pits, the openings of which are filled by the tips of the setae. Clasper setae are straight, or nearly so, or with some curvature of a short ental portion. The shaft is ornamented ectally with irregularly interrupted circles of fine spines and tapers to a rather blunt tip which may be somewhat concave on one side.

INTERNAL ANATOMY: Septa 7/8–17/18 thickly muscular, muscularity of septa gradually decreasing anterior and posterior to that region. Body wall thick in i–xx, thickness of muscular portion gradually decreasing posteriorly.

Gut, in viii–xvii, with superficial, regularly spaced, red, transverse stripes that appear to be branches of the supra-esophageal trunk, deeply constricted at septal insertions and hence rather moniliform. An esophageal valve of the usual sort was not recognized, narrowed regions at insertions of 15/16, 16/17, 17/18, or even 24/25 appear, in different individuals, to be valvular. Gut slightly widened and white in xix–xxiv where constrictions at septal insertions are slighter, in xxv–xxvii still wider, unconstricted and nearly spheroidal, with muscular layer thickest in xxv. The typhlosole, present from xxix, may be vertical and then thicker ventrally or dorsoventrally flattened almost into a thick band shape. The ventral margin posteriorly may be

rather regularly and fairly deeply scalloped. The typhlosole, in a posterior amputee of 340 segments, begins to attenuate in ccxx and is unrecognizable behind ccxxx.

Dorsal and ventral trunks (each single) become unrecognizable before reaching either end of the body. A supra-esophageal trunk is present in viii–xviii, posterior bifurcations ramifying in xix. A large branch from the trunk passes ventrally on each side of the gut just behind 7/8. No subneural trunk. A pair of large longitudinal trunks on the parietes just lateral to the nerve cord, and which are now tentatively called neuroparietals, communicate with each other, in each segment through a transverse connective on the body wall under the nerve cord. Each neuroparietal turns laterally almost at right angles in region of xxiv but shortly turns again anteriorly. A fairly large vessel from the supra-esophageal passes down to the parietes posteriorly in viii, turns laterally, and then appears to join the neuroparietal. Hearts large, lateral in viii–ix, latero-esophageal in x–xii, the last pair always (homoeotics included) in the segment in front of the one with ovaries. Nephridia large, reaching on parietes nearly to mD. Brain, apparently in iii–iv, anteroposteriorly elongated, anterior face concave, a fairly deep median incision on posterior face.

Holandric. Male funnels large, plicate. Seminal vesicles in contact over dorsal trunk and filling coelomic cavities, four pairs, in ix–xii. Ovaries plicate. Spermathecae sessile or within the parietes and covered over by peritoneum. Ampullae, when distended, may reach through entire length of a segment.

One small gland (?), on posterior face of 12/13, is just median to each ovary. Similar structures, each usually with several discrete and shortly digitiform lobes, are present on posterior faces of 13/14–24/25 or 25/26.

REPRODUCTION: As sperm are matured and exchanged in a copulatory act, reproduction is assumed to be sexual and biparental.

HOMOEOSIS: Female pores in two specimens on xiii and clasper anlage in xvii–xix. Female pores in one juvenile on xv and clasper anlage in xix–xxi (posterior homoeosis). Regeneration stigmata externally unrecognizable in either of those specimens.

The anterior homoeosis could have resulted from regeneration of one segment less than had been amputated. The posterior homoeosis could have resulted from regeneration of one segment more than had been amputated, hypermetry having been recorded for head regenerates in several species of earthworms. Posterior homoeosis also may

result, at least in the Lumbricidae, from halving of mesoblastic somites during embryonic development.

REGENERATION: Tail regenerates appear to be young. Five stages were recognized.

1. Anus terminal but continued onto dorsum and clear across last substrate segment. The lobe is on the posterior face of the worm at ventral margin of the anus.

2. Regenerate smaller than last substrate segment, with dorsal anus and posterior lobe but without recognizable indications of metameric differentiation.

3. Regenerate *ca.* 1 mm. long. Three or four rudimentary segments apparently delimited anteroventrally.

4. Regenerate *ca.* 2 mm. long. Two or three segments delimited in front of anterior end of anus, further furrows in ventrum presumably marking off rudiments of other segments.

5. Regenerate with dorsal anus but no posterior lobe. Seven setigerous segments in front of the anus.

The last segment of one posterior amputee still has four of its setae. The anus already is terminodorsal and reaches forward nearly to anterior margin of the last substrate segment.

The whole of the last substrate segment appears to become reorganized into a region of rapid segment production.

Two worms lack most of one clasper. Healing, presumably after amputation close to the body, had left a central aperture on ventral face of the stump. Healing in the other case, presumably after amputation about 4 mm. away from the body, had left no perforation. No indication of ability to regenerate amputated portions of the clasper was recognized.

GROWTH STAGES: Claspers apparently attain maximum development before appearance of the clitellum. Early stages of clasper development are shown by some of the larger juveniles. In smaller juveniles, ventral setae of xviii-xx are equally protuberant and apparently of the same size and shape as in adjacent segments. The following adolescent stages are present.

1. The *a* setae of xviii-xx now unrecognizable and presumably dehisced.

2. Slight transverse tumescences now recognizable on each side, just lateral to *A* and behind each equator of xviii-xx. Tips of two to six fine, regularly spaced setae may be recognizable in a transverse row just lateral to *A* but not reaching *B*.

3. A single longitudinal tumescence, just lateral to *A* on each side,

now reaches to or nearly to equators of xviii and xx. Intersegmental furrows 18/19 and 19/20 still visible across the tumescences.

4. Longitudinal tumescences still higher, intersegmental furrows quite unrecognizable on a major portion of each ridge. A pore, on median side of the ridge near ventral face (one specimen only), on a portion presumably belonging to xix, may be the male opening.

The *b* setae (and their follicles?) of xviii–xx seemingly are lost but at various stages. The “formative” cells in clasper follicles may then be descendants of those that were present in the *a* follicles before development of the appendages began.

REMARKS: The neuroparietal trunks are not of uniform size throughout but vary from one side to the other, or from one region to another on the same side, presumably according to the amount of blood within at time of preservation. The “parietal” section of the name is included to indicate distinction from the “lateral neural” or “extra-neural” trunks, much smaller vessels actually on the nerve cord in species provided with a subneural. The neuroparietals may be comparable to the more widely separated lateroparietal trunks of certain octochaetines that also lack the subneural vessel. Very much, however, remains to be learned about the comparative anatomy of the circulatory system of earthworms.

The abbranchiate Stanleyville worms are referred to *A. emini* because of the large numbers of spermathecae and the locations of their apertures. The number of pores at an intersegmental furrow in this species may be as many as 25, and the locations at which pores now have been recorded are: 50/51, 52/53, 55/56, 57/58, 58/59, 65/66–70/71, 72/73, 73/74, 74/75, 75/76, 78/79, 84/85. All spermathecae in previous material supposedly have been in the clitellar region, but receptacles that are rudimentary, vestigial, empty, or that are concealed within the parietes and are visible only in sections or after stripping off the longitudinal musculature may, like their pores, not have been seen. The clitellum has been said to be at the following positions: 50/51, 51/52, 53/54, 54/55, 55/56, 56/57, 65/66, 70/71, 78/79–87/88, 89/90, 90/91, 93/94, 100/101, 102/103, 121/122. Boundaries, however, are indefinite, and if determinable only in microscopic sections or after special staining may be anterior, if not also posterior, to recorded levels.

Alma sp.

SPECIMENS EXAMINED: Stanleyville, Belgian Congo, April, 1915, 7-0-0; H. Lang and J. Chapin. (A.M.N.H. No. 3568.)

EXTERNAL CHARACTERISTICS: Length, 70–140 mm. Diameter, 2–5 mm. Anus dorsal and with posterior lobe (four specimens, others posterior amputees). Female pores probably at *B* on xiv. The *a* setae of xviii–xx unrecognizable (deeply retracted or dehisced). Claspers or rudiments thereof lacking.

Gills, on dorsum just median to *D*, present through 75–85 segments from some distance in front of the anus. Unbranched gills are almost spheroidal (rudimentary or strongly contracted?) to digitiform. Branching usually is near the base, each of the two to five branches digitiform.

INTERNAL ANATOMY: Gut valvular in xxv (?), much widened and white in xxvi–xxvii or xxviii, muscularity best developed anteriorly in xxvi, thickness of muscular layer gradually decreasing posteriorly. Gut narrower behind xxviii.

REGENERATION: Tail regenerate, in two specimens, about 1 mm. long, with dorsal anus and posterior lobe. The anus of the smaller regenerate without metameric differentiation is continued through all the last substrate segment. The anus extends only to the substrate in the larger regenerate, in which closely crowded furrows (presumably intersegmental) are recognizable ventrally. A regenerate in two specimens is as yet represented only by a small round lobe on the ventral side of a terminal opening into the gut. Another specimen is an unregenerate posterior amputee.

REMARKS: Clasper development from segments xviii to xx may be indicated by absence of the *a* setae.

The gills provide the evidence for specific distinctness from other juveniles secured at the same time or place.

Only one of the three branchiate species of *Alma* has been recorded from the Belgian Congo. The gill-bearing Stanleyville juveniles accordingly may be of *eubranchiata* Michaelsen, 1910, a little-known species.

FAMILY EUDRILIDAE

EUDRILUS KINBERG, 1866

Eudrilus eugeniae Kinberg, 1866

Eudrilus eugeniae, GATES, 1942, Bull. Mus. Comp. Zool. Harvard College, vol. 89, p. 137.

SPECIMEN EXAMINED: Georgetown, British Guiana, in polluted soil near houses in the city, 1957, 0-0-1; J. R. Ramsammy. (A.M.N.H. No. 3564.)

This species, originating in tropical Africa and until very recently known only from the tropics, has been raised and distributed in the

United States for several years by earthworm culturists. Sales appear to be mostly to anglers for bait. Escapes of live specimens into natural environments must have been numerous. As yet, however, there are no records to indicate acclimatization and permanent colonization in mainland states.

